W and Z Physics at Tevatron

XLII Rencontres de Moriond

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Julien Donini
University of Padova, INFN

Istituto Nazionale di Fisica Nucleare

Introduction: W/Z Physics

Leptonic decays

W mass: constraint on Higgs mass

W width: useful tests of SM. Direct and indirect measurements.

Drell-Yan $qq \to ll$, A_{FB}: high m_{ll} sensitive to New Physics, interference Z/γ^*.

PDF (parton distribution function) constraints

- x-section $W \to l\nu$, $Z \to ll$
- differential x-section, Z/γ^* rapidity
- W asymmetry.
- P_t distribution.

Hadronic decays

Jet Energy Scales (JES)

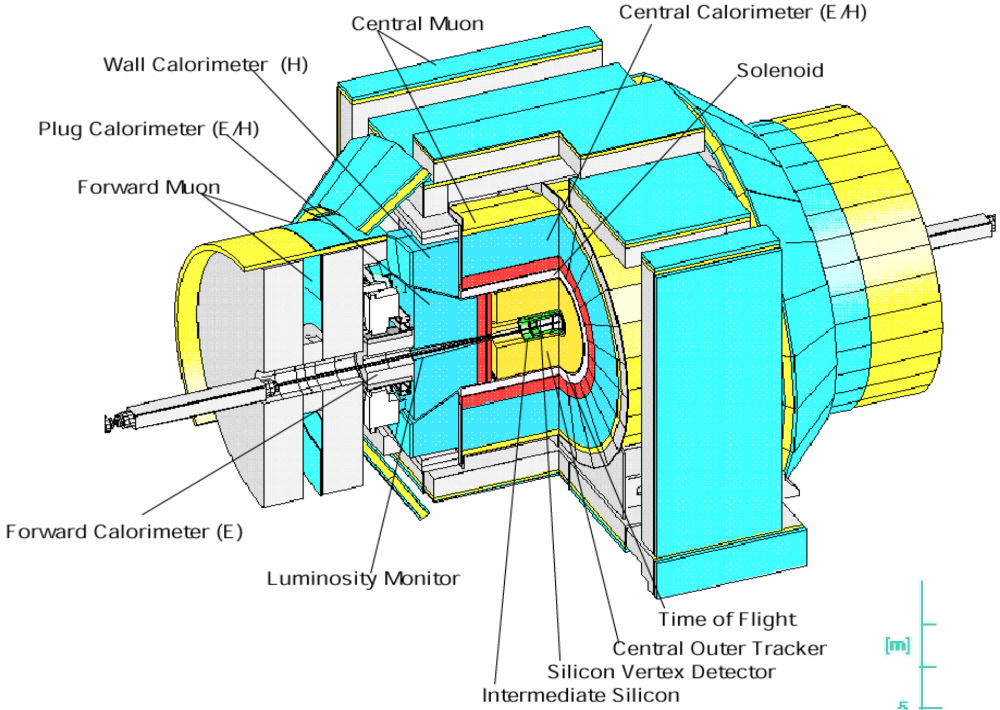
$W \to jj$: constraint JES, Top mass.

$Z \to bb$: b-specific JES, resolution studies. Top, Higgs.

Results presented in this talk:

- **$Z \to bb$** signal (CDF 0.6fb^{-1})
- **$Z/\gamma^* \to e^+e^-$ rapidity** distribution (CDF 1fb^{-1}, DØ 0.4fb^{-1})
- **Z P_t** distribution (DØ 1fb^{-1})
- **W charge asymmetry** (DØ 0.2fb^{-1})

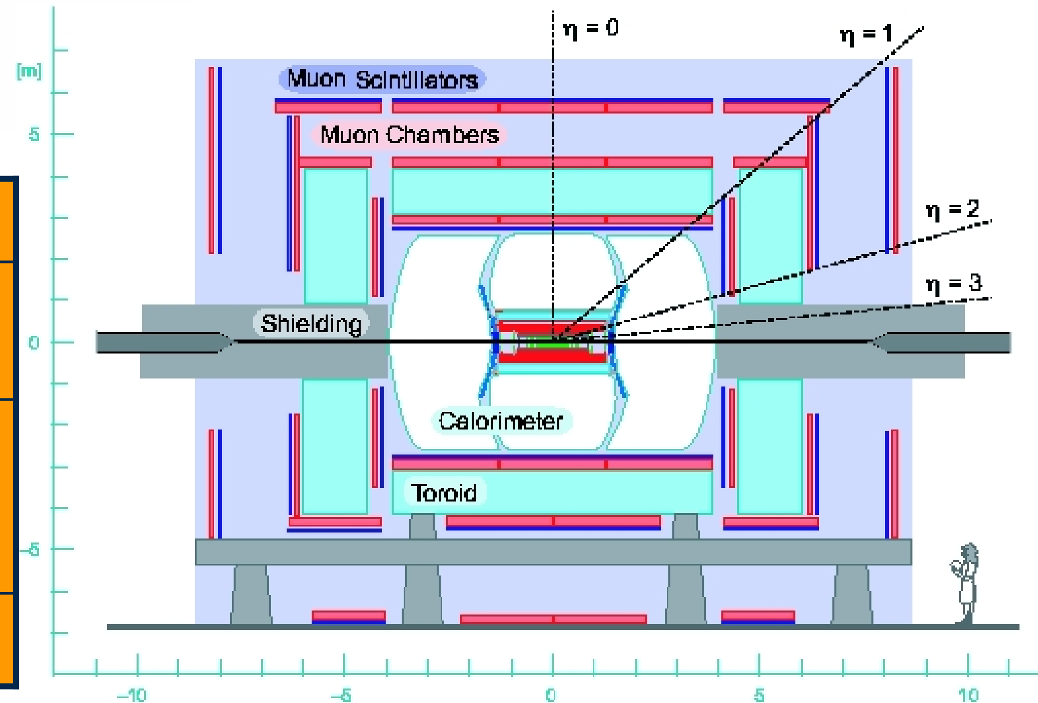
CDF/DØ Experiments



CDF/DØ detectors

- Silicon vertex tracker
- Solenoid
- Calorimeter (E/H)
- Muons

	CDF	DØ
Tracking	Drift Chamber + Si, $\lvert\eta\rvert < 2$	Fiber + Si $\lvert\eta\rvert < 3$
Calorimetry	Pb/Steel + Scintillator $\lvert\eta\rvert < 3.6$	Ur + Liquid Ar $\lvert\eta\rvert < 4$
Muons	$\lvert\eta\rvert < 1$	$\lvert\eta\rvert < 2$



Z→bb signal and b-JES

Only triggerable W/Z→jj physical process.

Z→ bb signal was observed in Run I/II.

Large Z^0 →bb signal: x-section, measure b-specific properties.

b-jets

different from generic (light) jets

- **harder fragmentation**
- **semi-leptonic decays**

Play crucial role in **Top** and **Higgs** physics.

Use Z^0 →bb resonance as a tool to:

- **measure specific data/MC energy scale of b-quark jets:**

  → Reduction of uncertainty in b-JES helps **Top quark mass** measurement

- **improve b-jet energy resolution**

  → **develop and test algorithm to improve b-jet energy resolution:** important for low mass **Higgs searches**.

Z→bb signal and b-JES

b-specific JES = scale factor between data and MC Z→bb signal.

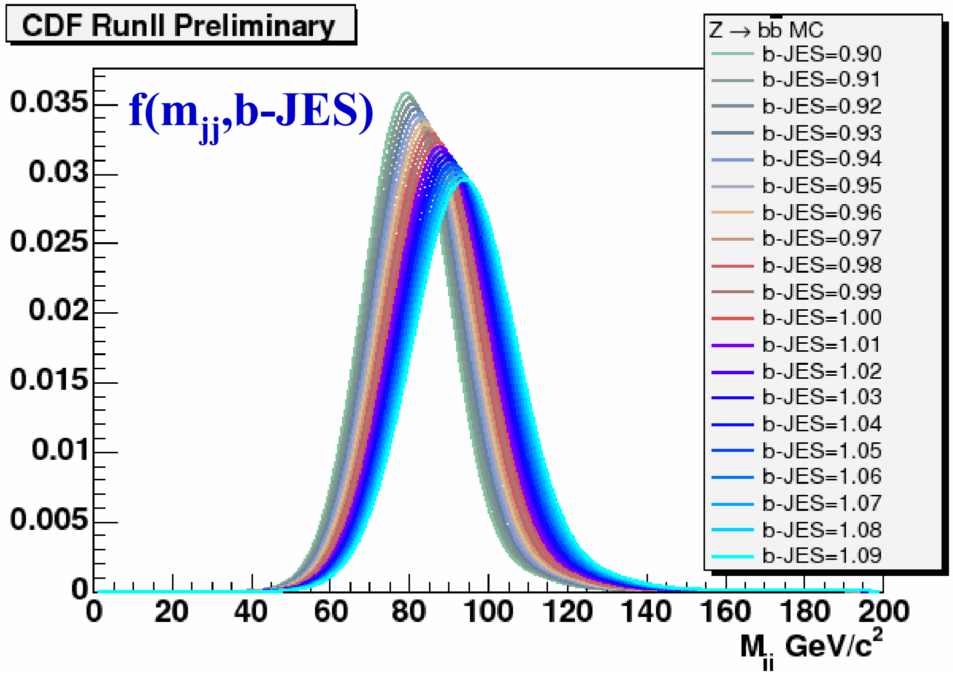
Unbinned likelihood technique, free parameters: N_{signal} and b-jet JES factor.

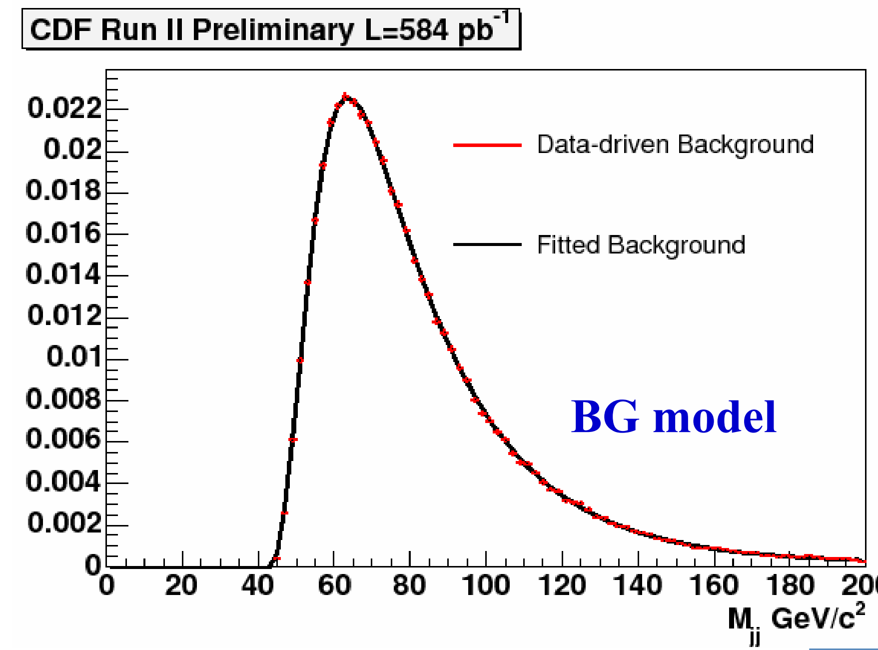
MC signal templates (Pythia)

Signal shape **f(m_{jj},b-JES)**

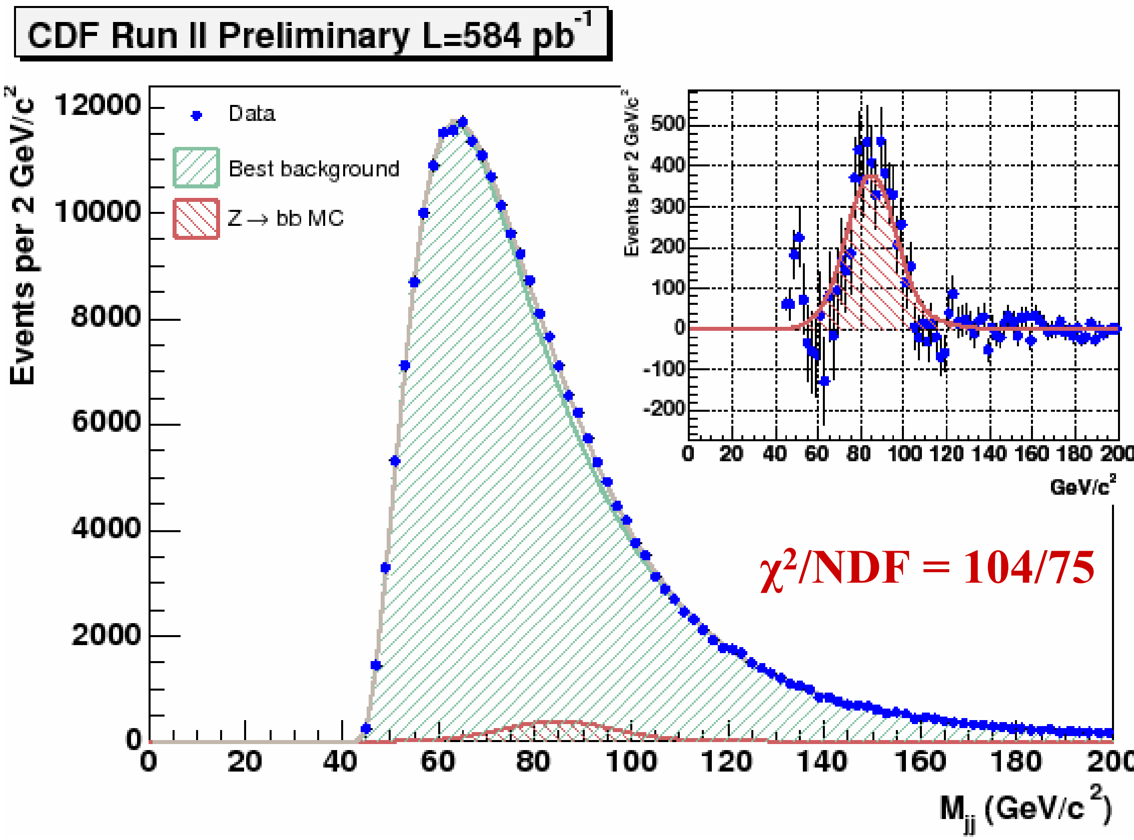
Data-driven BG model: BG enriched sample, tag rate function.

BG models not unique: sideband fit criteria, use all BG model for syst. error.





Z→bb Results (584 pb^{-1})



Results

b-JES = $0.974^{+0.020}_{-0.018}$ (stat.+syst.)

$N_{sig} = 5674^{+1540}_{-725}$ (stat.+syst.) events

Systematics related to BG models are dominant.

N expected signal used as a constraint to **improve the fit precision** on b-JES factor.

Extraction Z→bb signal and b-specific JES measurements: first step !

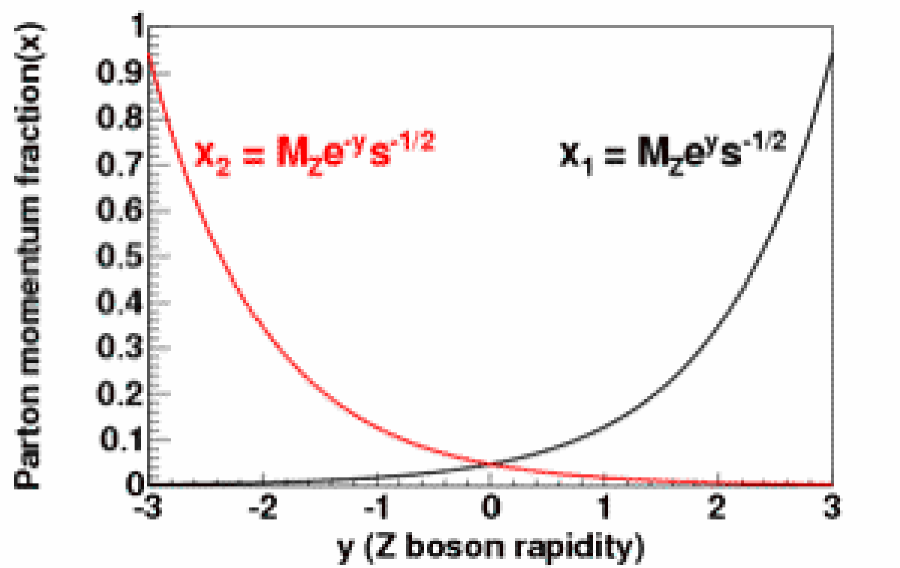
Applicability of b-JES to other analysis (Top, Higgs, etc) under study.

$Z/\gamma^* \to e^+e^-$ Rapidity Distribution

Study of kinematic distributions of Z/γ^* provide stringent test of QCD calculations.

Momentum fraction carried by partons related to Z rapidity:

$$y = \frac{1}{2}\ln\frac{E+P_L}{E-P_L} \qquad x_{1,2} = \frac{M_{Z/\gamma^*}}{\sqrt{s}}e^{\pm y}$$

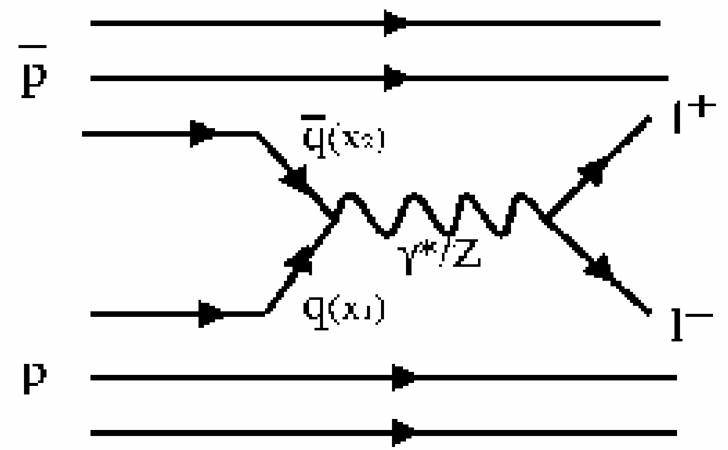


Forward regions (|η|>1.5) most difficult to test

Differential x-section measured using $Z/\gamma^* \to e^+e^-$ decay

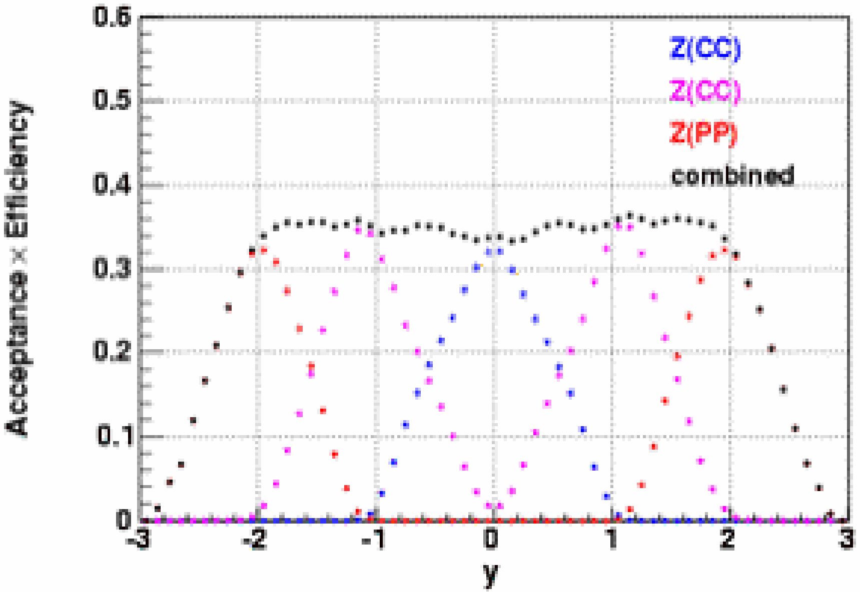
→ lepton accurately reconstructed

→ small backgrounds



$Z/\gamma^* \rightarrow e^+e^-$ Results (1.1 fb^{-1})

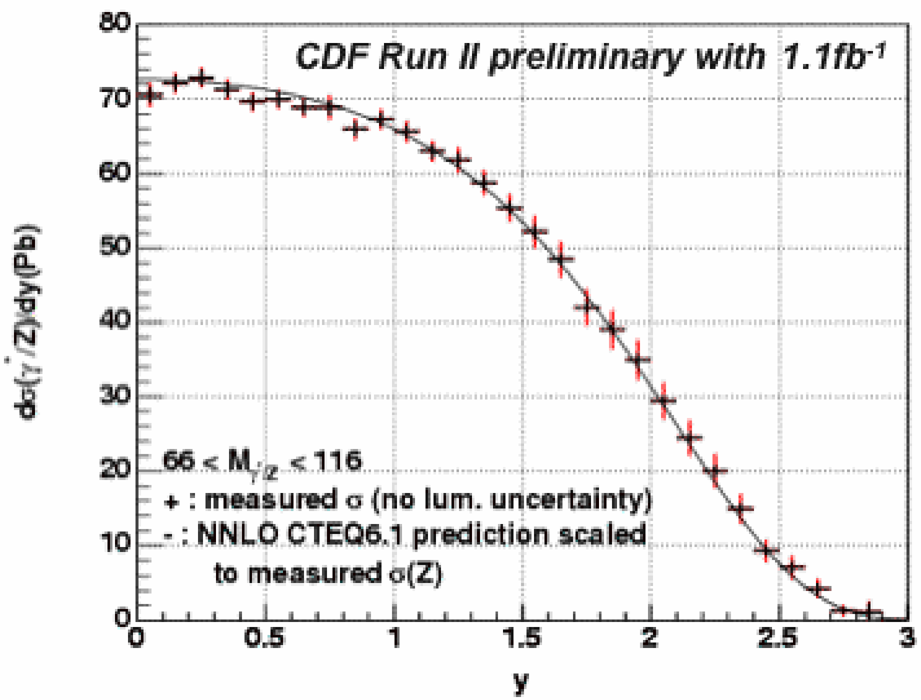
Different topologies: CC: $|\eta|<1.1$, PP: $1.2<|\eta|<2.8$, CP



Trigger, acceptance efficiency studies (data, MC).

BG sources: dominant is QCD dijet. Estimated from data. Other processes (diboson, tt, etc) estimated with MC.

Main syst. error: silicon tracking eff.

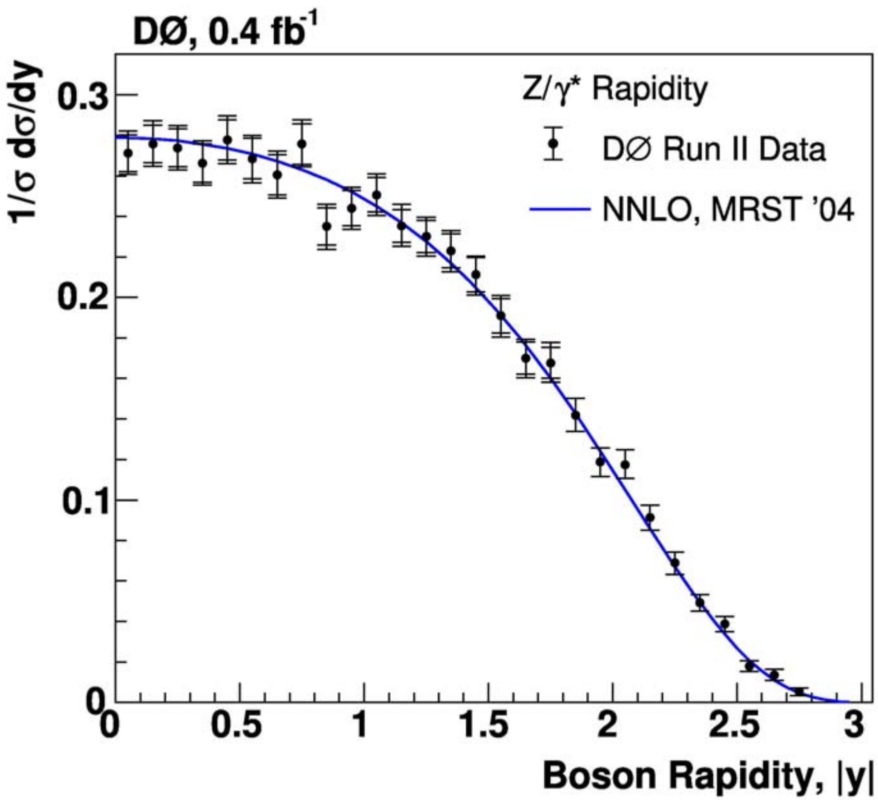


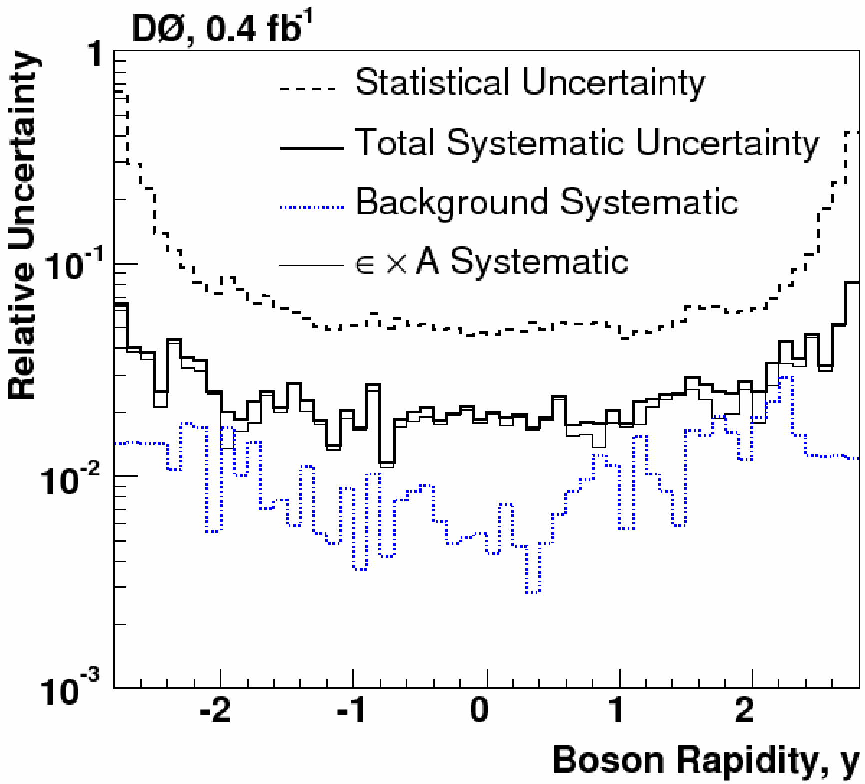
Results:

σ_{Tot} **= 265.9 ± 1.0 ± 1.1 pb**

Compare data/theory: NNLO calculation with NLO CTEQ6.1 PDF most consistent with data.

$Z/\gamma^* \rightarrow e^+e^-$ Results (0.4 fb^{-1})





Statistical uncertainty is dominant.

NNLO calculation with MRST2004 NNLO **PDF agrees well with data.**

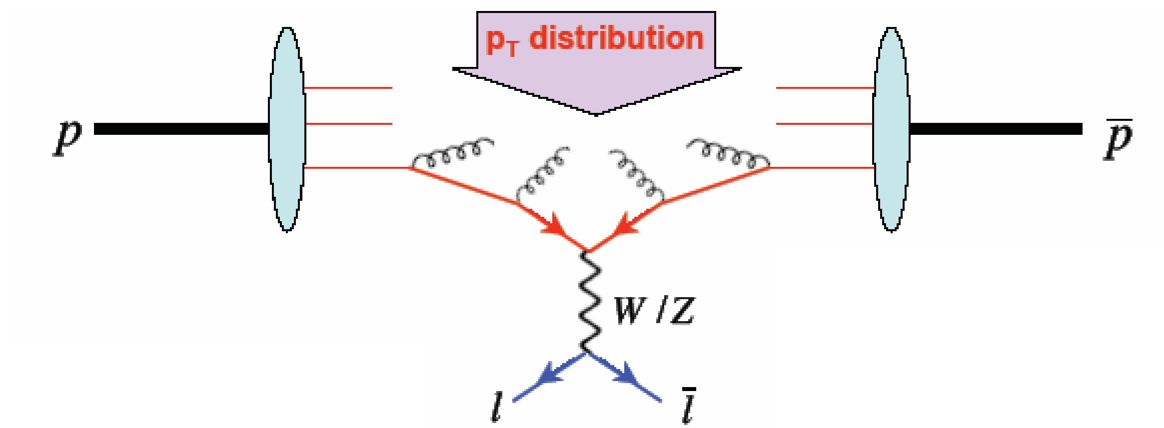
***Submitted to PRD*: Fermilab-Pub-07-040-E**

Z Boson P_t Measurement

Precision measurement of Z boson transverse momentum:

- test of theory of weak boson production
- reduce theoretical uncertainty on W mass

Measure Z P_t in $qq \rightarrow Z/\gamma^* \rightarrow e^+e^-$ process.

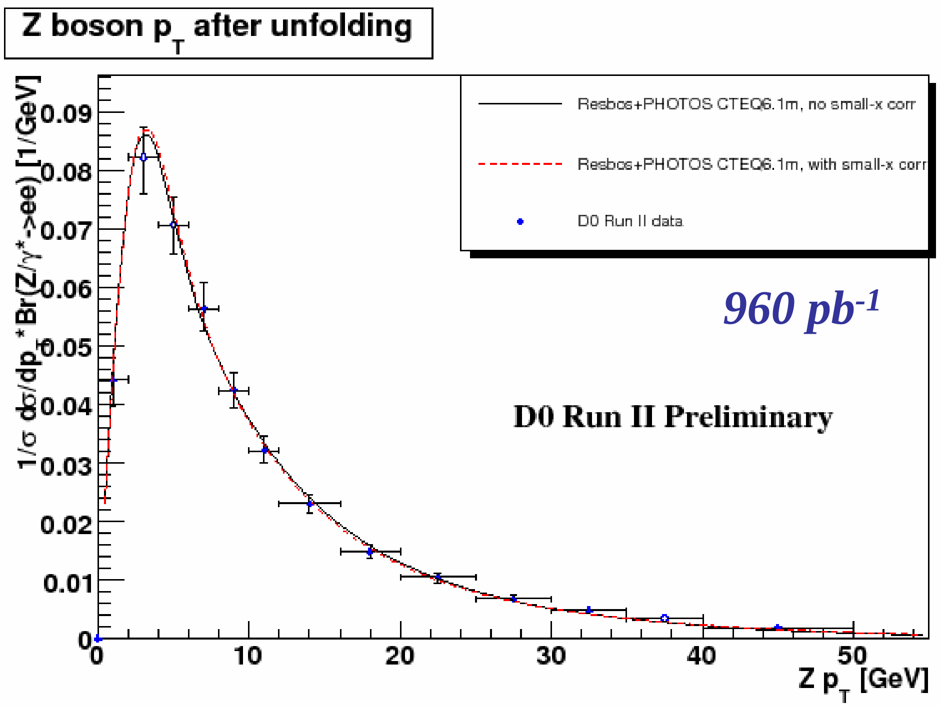


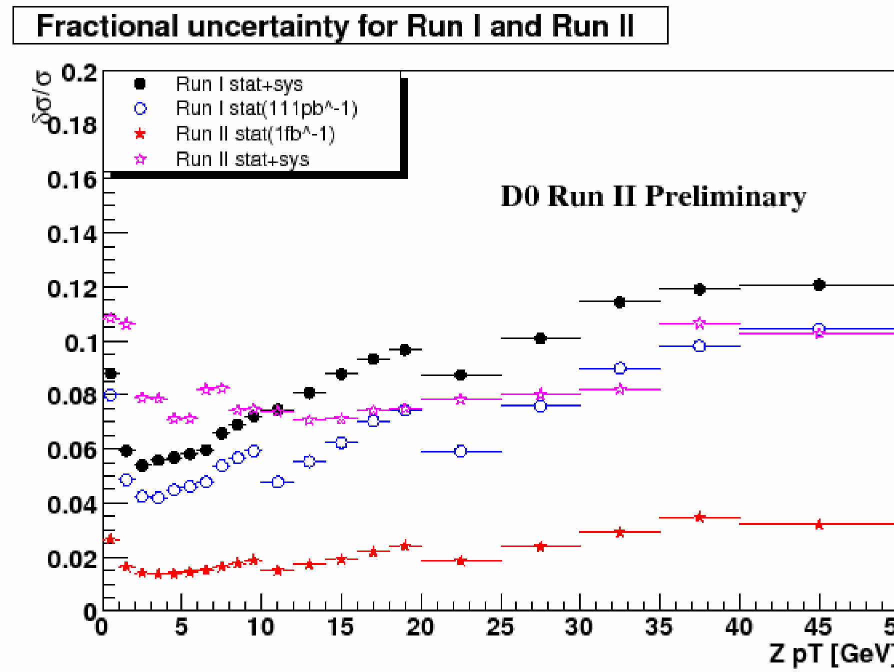
Event topology CC: $|\eta|<1.1$, PP: $1.5<|\eta|<3.2$, CP.

Main background: QCD dijet.

Z Boson P_t Results (~1 fb^{-1})

Z P_t spectrum smeared from detector resolution effects → unfolding.





Largest syst. uncertainty related to lepton ID.

Syst. uncertainties under study, expected to be greatly **reduced** in near future.

W Charge Asymmetry

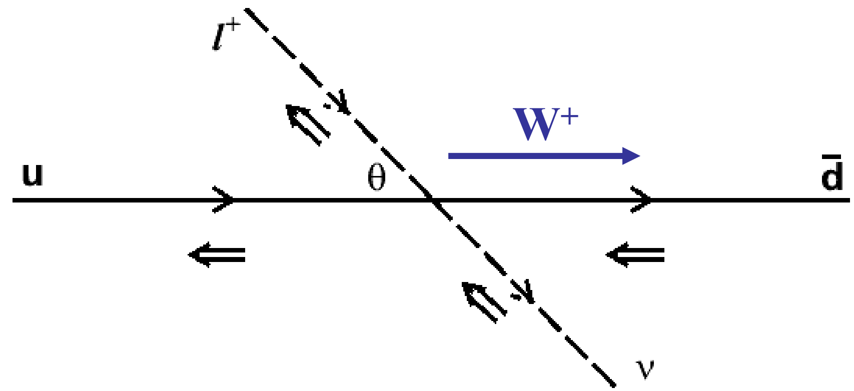
W$^{\pm}$ rapidity measurement provide useful information about PDF of u and d quarks.

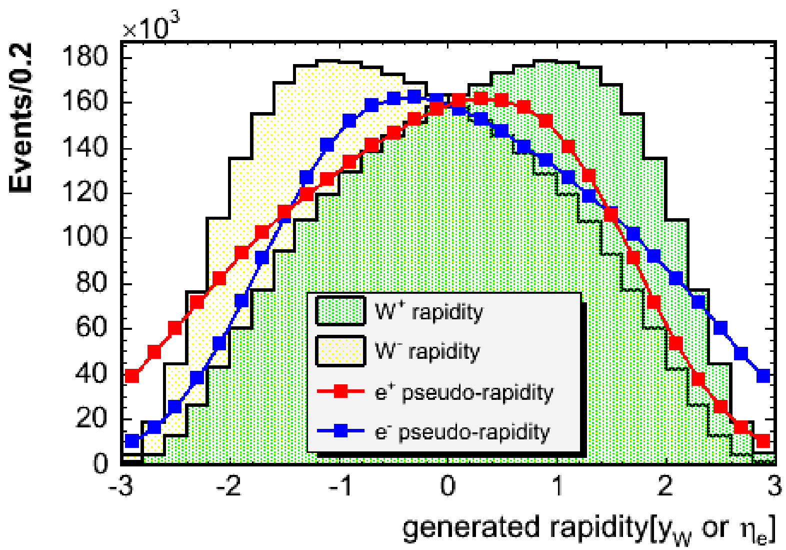
$$x_{1,2} = \frac{M_W}{\sqrt{s}} e^{\pm y}$$

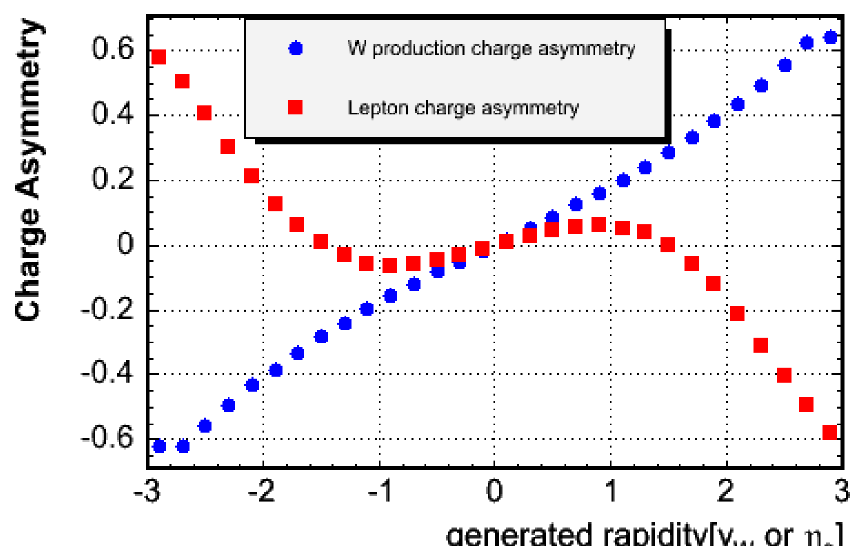
Different u, d momentum: **W$^{\pm}$ produced asymmetrically.**

➔ charge asymmetry of decaying l,ν

But **V-A** interaction: **reduces** the observable asymmetry in the **lepton rapidity distributions.**

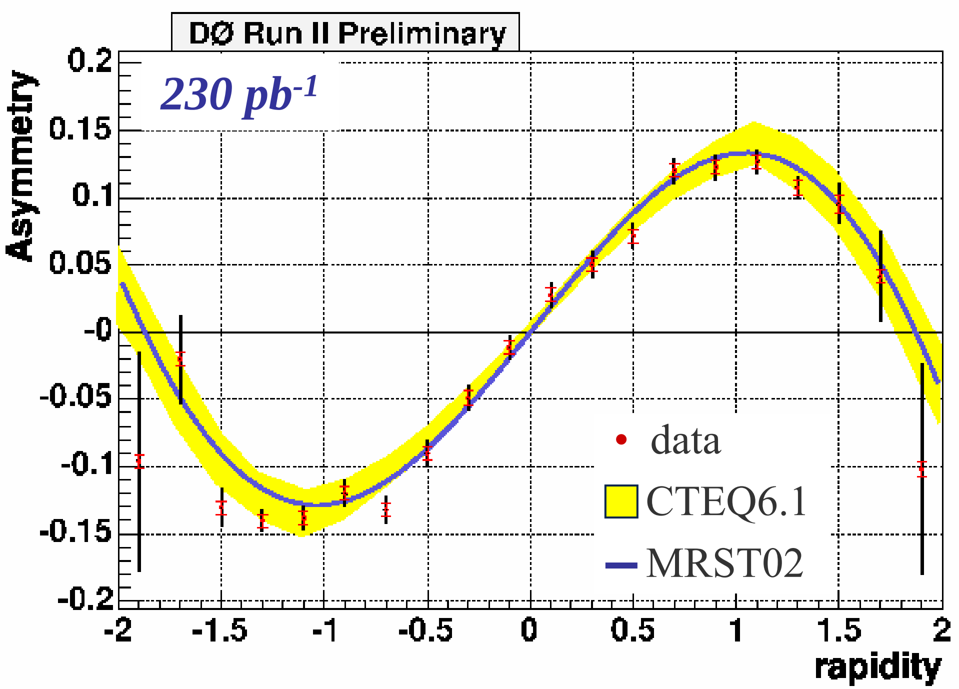


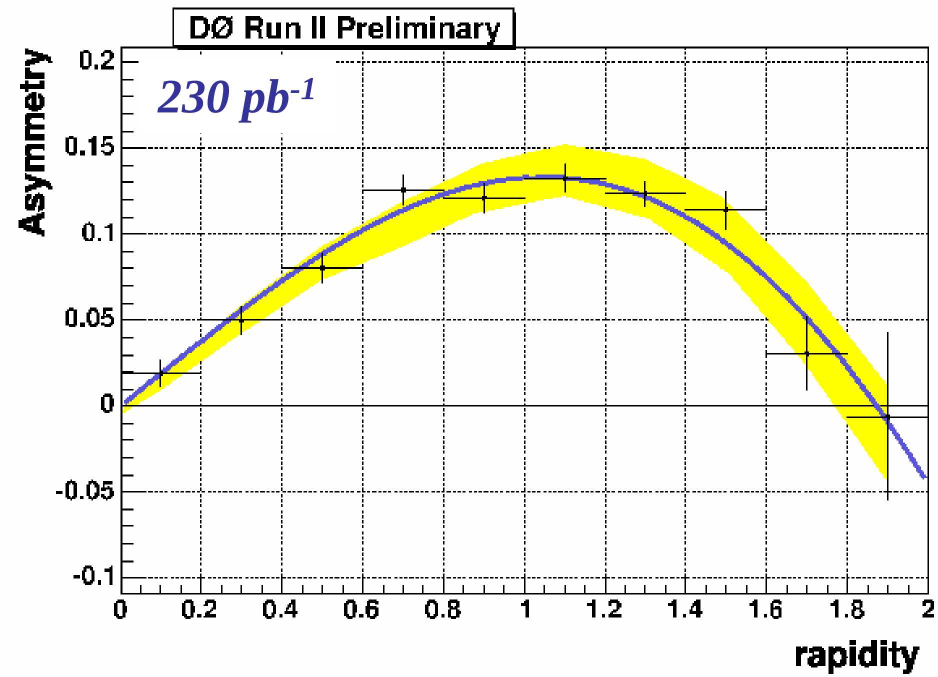




W→μν Charge Asymmetry (230 pb^{-1})

Muon charge asymmetry:





Error bars are **dominated by stat. uncertainty**. Comparable to PDF uncertainty.

Result sensitive to u, d quark momentum in $0.005 < x < 0.3$ range.

Complementary to CDF Run II electron asymmetry analysis (PRD 71, 051104).

Measurement can help constraint the PDFs: reduce error of some PDF parameters.

Conclusions

$Z \rightarrow bb$: preliminary CDF II signal and first b-JES measurement.

Applicability of b-JES for other analysis is under study.

Large W/Z samples collected at Tevatron allow many different electroweak measurements.

Syst. can also be improved in some measurements.

Measurements not syst. limited. Stat. uncertainty will be greatly reduced with increasing amount of data available.

→ Test **theory**, reduce errors on **W mass**, constrain **Higgs mass!**

BACKUP

Z Boson P_t Measurement

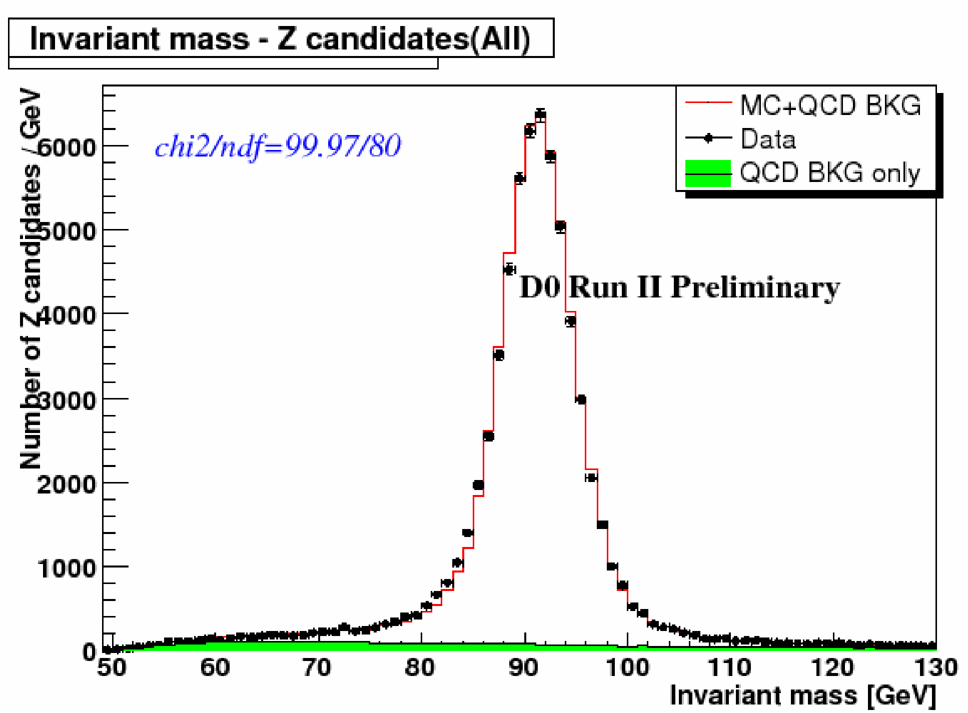
Event selection:
- two isolated EM clusters, electron ID
- high transverse momenta
- $70 < m_{ee} < 110$ GeV.
- track matching of $e^{\pm}$ candidates

CC: $|\eta|<1.1$, PP: $1.5<|\eta|<3.2$, CP

Electron triggers.

~64000 evts selected

Electron selection efficiencies (lepton ID, trigger): tag and probe method.



Main background: QCD dijet.

Construct inv. mass shape from BG enriched sample

➔ then fit data

Other BG (dibosons, etc): negligible.

Z_BB Trigger

The trigger in period 2 is based on high P_t XFT tracks and calorimetry at L1, clusters and displaced SVT tracks at L2 and reconstructed jets and large impact parameter tracks at L3. More explicitly:

- L1: 1 central tower with $E_t > 5$ GeV
  two XFT tracks, one with $P_t > 5.48$ GeV$/c$ and one with $P_t > 2.46$ GeV$/c$.

- L2: veto clusters with $E_t > 5$ GeV, $|\eta| > 1.1$, $|\eta| < 3.6$;
  require two $E_t > 3$ GeV clusters with $|\eta| < 1.1$;
  two SVT tracks with $P_t > 2$ GeV, $d_0 > 160\ \mu m$, $d_0 < 1000\ \mu m$, $\chi^2 < 15$;
  require SVT tracks to traverse adjacent or same SVX half-barrels.

- L3: two $R = 0.7$ jets with $E_t > 10$ GeV, $|\eta| < 1.1$;
  two tracks with $P_t > 2$ GeV, $d_0 > 160\ \mu m$ and $d_0 < 1000\ \mu m$, $|\eta| < 1.2$;
  two tracks with $P_t > 1.5$ GeV, $d_0 > 130\ \mu m$ and $d_0 < 1000\ \mu m$, $|\eta| < 1.2$, and
  IP significance $s(d_0) > 3$;
  the two $P_t > 1.5$ GeV tracks must have $\Delta z < 5\ cm$.